

Customer No. 01333

Commissioner for Patents,
ATTN: BOX PATENT APPLICATION
Washington, D. C. 20231

Date: December 13, 2000

PROOFING HEAD AND PROOFER PRINTER APPARATUS

FIELD OF THE INVENTION

This invention relates to image proofing systems, more particularly to a proofing apparatus and a proofing head assembly used to prepare color
5 correct samples of printed materials.

BACKGROUND OF THE INVENTION

In the printing industry, it is common to provide a sample of an image to the customer for approval prior to printing a large number of copies of the image using a high volume output device such as a printing press. The sample
10 image is known as a "proof". The proof is used to ensure that the consumer is satisfied with the contents, composition and color gamut and tone characteristics of the image.

It is not, however, cost effective to print the proof using high volume output devices of the type used to print large quantities of the image. This
15 is because it is expensive to set up high volume output devices to print an image. Accordingly, it has become the practice in the printing industry to use digital color printers to print proofs. Digital color printers render color prints of images that have been encoded in the form of digital data. This data includes code values indicating the colors to be printed in an image. When the color printer generates
20 the printed output of an image, it is intended that the image recorded on the printed output will contain the exact colors called for by the code values in the digitally encoded data.

In practice, it has been found that the colors in the images printed by digital color printers do not always match the colors printed by high volume
25 output devices. One reason for this is that variations in ink, paper and printing conditions can cause a digital color printer to generate images with colors that do not match the colors produced by a high volume output device using the same values. Therefore, a proof printed by a digital color printer may not have colors that match the colors that will be printed by the high volume output device.

30 Accordingly, digital color printers have been developed that can be color adjusted so that they can mimic the performance of high volume output devices. Such adjustable color printers are known in the industry as "proofers".

Two types of adjustments are commonly applied to cause proofers to produce visually accurate proofs of an image: color calibration adjustments and color management adjustments.

5 Color calibration adjustments are used to modify the operation of the proofer so that the proofer prints the colors called for in the code values of the images to be printed by the proofer. These adjustments are necessary to compensate for the variations in ink, paper and printing conditions that can cause the colors printed by the proofer to vary from the colors called for in the code values. To determine what color calibration adjustments must be made, it is
10 necessary to determine how the proofer translates code values into colors on a printed image. This is done by asking the proofer to print a calibration test image. The calibration test image consists of a number of color patches. Each color patch contains the color printed by the proofer in response to a particular code value. The stand-alone calibration device measures the colors in the test image. The
15 color of each color patch is compared to code values associated with that patch and the comparisons are used to determine what adjustments must be made to the proofer to cause the proofer to print desired colors in response to particular color code values.

20 Color management adjustments are used to modify the operation of the proofer so that an image printed by the proofer will have an appearance that matches the appearance of the same image as printed by a high volume output device. The first step in color management is to determine how the high volume output device converts color code values into printed colors. This is known as characterization. To characterize a high volume output device it is necessary to
25 obtain a characterization test image. The characterization test image can be printed by the high volume output device. However, if it is known that the high volume output device converts code values into printed colors in accordance with an industry standard proofing system such as MatchPrint TM or Cromalin TM, then a test image printed in accordance with that standard can be used for
30 characterization purposes.

In either case, the characterization test image is submitted to the stand-alone color management device. The color patches on the characterization

test image are compared to the color code values associated with the patches. This comparison is used to determine the adjustments that must be made to cause the proofer to print images having the same color gamut and tone characteristics as the images printed by the high volume output device. The proofer is then adjusted accordingly.

In this manner, the proofer is adjusted so that the proofer is properly calibrated to render images having the colors called for in the code values in the image to be proofed and is also adjusted to modify the code values in the image to be proofed in accordance with the profile for the output device.

Thus, the proofer renders images having the colors that will appear the same as the colors in the images printed by output device.

It will be recognized that both calibration adjustments and color management adjustments are based upon objective measurements of the color gamut and tone characteristics of the test images printed by the proofer and by the high volume output device.

Various devices are used to measure the color content of an image. The most common devices are the densitometer and the color scanner. These devices typically analyze the color content of the light reflected by an image by dividing light into a set of primary colors, such as red, green and blue. These devices divide light into primary colors by passing the light through a set of colored filters. By measuring the intensity of the light in each primary color, it is possible to objectively measure the color content of an image.

A special form of densitometer, the colorimeter, can also be used to objectively measure the color gamut and tone characteristics of an image.

Colorimeters are designed to objectively measure the color of a sample in a way that approximates human visual response. This is accomplished by the use of filters that are chosen to mimic human visual response.

A more accurate device for measuring color for calibration and color management purposes is the spectrophotometer. The spectrophotometer measures the reflectance or transmittance of an object at a number of wavelengths throughout the visible spectrum. More specifically, a spectrophotometer exposes a test image to a known light source and then analyzes the light that is reflected by

the test image to determine the spectral intensity of the sample. A typical spectrophotometer is capable of measuring a group of pixels in an image and includes an apparatus that measures the light that is reflected by a portion of an image at a number of wavelengths throughout the visible spectrum to obtain data that reflects the true spectral content of the reflected light. Because the spectrophotometer measures color with greater accuracy than do the other measurement devices discussed above, the spectrophotometer is preferred.

Thus, densitometers, colorimeters, color scanners, and spectrophotometers can be used for color measurement. However, these are typically stand-alone devices and the use of such devices during proofing is very costly. Part of this cost is created by the inherent redundancy of many of the systems used in these devices. For example, a stand-alone spectrophotometer, has an "X-Y" table to move the test image relative to the spectrophotometer. A digital color printer or proofer also contains an "X-Y" displacement mechanism for moving the paper and printing element or printhead. Similarly, both the spectrophotometer and the proofer contain separate electrical control systems, motors and other components. Thus, the total cost of the proofing system including a separate stand-alone color measurement device and a proofer is high and can be in excess of more than U.S. \$10,000.00.

Installation and maintenance costs are also high because two separate devices, typically manufactured by different vendors, must be separately purchased, installed, and maintained. Finally, there is a significant labor cost associated with making calibration and color management adjustments to the proofer using a stand-alone color measurement device.

Accordingly, there are substantial cost and efficiency penalties associated with stand-alone proofing combinations and what is needed is an integrated proofing apparatus.

Special printers having integrated color scanners or densitometers for color calibration purposes exist. Examples of color calibration and correction systems of this type can be found in commonly assigned U.S. Patents 5,053,866, and 5,491,586. These patents show specially designed printing systems for generating a color image and adjusting the color content of subsequent images

based upon the colors printed in the color image. However, these specially designed systems also use redundant structures for printing and color measurement and do not teach or suggest color management capabilities.

5 It will also be recognized that many high quality color digital printers exist. However, these printers are not designed with integral proofing capabilities. Thus, what is also needed is a proofing head having calibration and color management capabilities and that can be readily integrated into an existing printer.

10 Accordingly, it is an object of the present invention to provide a proofer that is low in cost and is easily maintained.

It is also an object to provide a proofer that substantially automates the proofing process.

15 It is also an object of the present invention to provide a proofing head that can be readily incorporated into a printer of conventional design to permit the printer to act as a proofer.

SUMMARY OF THE INVENTION

20 The present invention resides in a proofing printer for generating a proof and a proofing head assembly. The proofing head assembly comprises a color light analyzer and a color printhead joined by a housing that directs the color light analyzer and the printhead at a media. A controller is provided to drive the color light analyzer to make color measurements of an image and to instruct the printhead to render images on a receiver media. The controller can adjust the colors printed by the printhead so that an image printed by the printhead will match the appearance of the same image as printed by another output device. The proofing printer assembly of the present invention combines the proofing head with a media advance and translation mechanism. Certain embodiments of the proofing printer self-calibrate and automatically characterize another output device. One embodiment of the proofing head of the present invention is adapted to be incorporated into color printers without color calibration and color management capabilities.

25

30

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows a drawing of the proofing process using a stand-alone color measurement device according to the prior art.

Fig. 2 shows a schematic diagram of a proofer of the present invention.

5 Fig. 3 shows an expanded view of the proofer of Fig. 1 with various components exhibited in cross section.

Fig. 4 shows a detailed view of a portion of the proofer of Figs. 2 and 3.

10 Fig. 5 shows a diagram of another embodiment of the present invention.

Fig. 6 shows an embodiment of the proofing head of the present invention for use with a conventional printer.

DETAILED DESCRIPTION OF THE INVENTION

15 Fig. 1 shows a drawing of the proofing process using a stand-alone color measurement device according to the prior art. The process of making calibration adjustments to the proofer 10 begins when the proofer 10 renders a calibration test image 16. Calibration test image 16 contains a multiplicity of color patches 17. Each of color patches 17 contains the color printed by proofer
20 10 in response to a particular color code value. The color content of the color patches 17 of test image 16 are measured using stand alone color measurement device 12. The color measurements are compared to the code values associated with the color patches 17. A set of calibration adjustments is determined using these comparisons. The operation of the stand-alone proofer 10 is then adjusted
25 so that the stand-alone proofer 10 renders a proof having the colors called for in the color code values for the proof.

The process of making color measurement adjustments to proofer 10 begins by obtaining a characterization test image 18. Characterization test image 18 is printed by high volume output device 14 or otherwise printed in
30 accordance with a standard color proofing system such as MatchPrint TM. Characterization test image 18 also contains a set of color patches 19. Each of color patches 19 is associated with a color code value. The location of each of

patches 19 on characterization test image 18 are defined by convention or by an industry standard e.g. American National Standards Institute standard IT8.7/3.

Characterization test image 18 is submitted to color measurement device 12. The color content of color patches 19 are measured and compared to the color code values associated with color patches 19. Comparison of the color code values to the colors printed in color patches 19 forms the foundation for building a mathematical model that predicts the color that high volume device 14 will print as a function of input code values. This mathematical model is inverted to allow prediction of image code values as a function of colorimetric values.

These two mathematical models relating code values to the color output of high volume output device 14 comprise the primary elements in what is known as a device profile. The device profile for high volume output device 14 is used to adjust proofer 10 to convert the code values in the image to be proofed into modified code values. Proofer 10 prints the proof using the modified code values.

It will be appreciated that substantial operator involvement is required to make calibration and color management adjustments using the stand alone devices. For example, an operator using a stand-alone color measurement device 12 is required to cause the high volume output device 14 to print test image 18. The operator must then wait for the test image 18 to be printed and convey test image 18 from the high volume output device 14 to the stand-alone color measurement device 12. The operator must then insert the characterization test image 18 into the color management device 12 to initiate the color measurement. Then the operator must wait for stand-alone color measurement device 12 to complete making the color measurements. Finally, the operator must adjust proofer 10 using the information from stand-alone color management device 12 to determine the adjustments that must be made to the proofer and to make those adjustments.

Fig. 2 shows a proofer 26 according to a preferred embodiment of the present invention. Proofer 26 comprises a proofing head 50 having a color light analyzer 20, a color printhead 56 and a housing 40 which joins light analyzer 20 to printhead 56. Printhead 56 may use any of several known technologies, such as, for example, ink jet, laser, impact, etc.

Housing 40 can comprise any of a box, closed frame, continuous surface or any other enclosure defining an interior chamber 41. In the embodiment of Fig. 2 and 3, housing 40 comprises a housing that holds both color light analyzer 20 and printhead 56. Housing 40 directs printhead 56 so that a
5 donor material such as an ink 52 ejected by printhead 56 is directed onto media 30. Housing 40 also directs the light analyzer 20 so that it receives light reflected by media 30.

The proofing head 50 is advanced along an X-axis by a translation unit 60. In the embodiment shown in Fig. 2, translation unit 60 comprises a motor
10 62 and a belt 64. Belt 64 is aligned along an X-axis relative to the media and supported at one end by a freely rotating support pinion 66 and a drive pinion 68. Drive pinion 68 is operated by motor 62. Housing 40 of proofing head 50 is fixed to belt 64 and moves in accordance with the motion of belt 64. Y-axis displacement of media 30 relative to proofing head 50 is provided by media
15 advance 70. Media advance 70 can comprise any number of well-known systems for moving media 30 within a printer including but not limited to a motor 72 driving pinch rollers 74, a motorized platen roller (not shown). Of course, other mechanical arrangements may be used to provide relative translation of proofing head 50 and media 30.

A controller 80 is provided and, as will be discussed in greater detail below, controller 80 drives the operation of printhead 56, light analyzer 20, translation unit 60, and media advance 70 during calibration, color management and printing operations. Controller 80 can comprise any of a programmable digital computer, a programmable logic controller, a series of electronic circuits or a
20 series of electronic circuits reduced to the form of an integrated circuit.

Fig. 3 shows another view of proofer 26 with proofing head 50 shown in partial cross section. As is seen in this view, housing 40 comprises an interior chamber 41 that contains both color light analyzer 20 and printhead 56. An opening 42 in housing 40 permits ink 52 to flow from printhead 50 during
30 printing operations to form an image on a media 30 positioned in a media plane 37.

Opening 42 in housing 40 also permits light to pass between a media 30 positioned in a media plane 37 and color light analyzer 20 during color management and calibration operations. In one embodiment, housing 40 directs the printhead 56 so that ink ejected by the print head flows onto one portion of a media. In this embodiment, the housing 40 directs the color light analyzer to collect light reflected by a second portion of the media 30. The first portion is adjacent to the second portion. However, in an alternative embodiment the first and second portion are separate.

Printhead 56 preferably comprises ink jet nozzles 54 for ejecting colored ink droplets 52 onto media 30. In such a design, colored ink is supplied to the printhead 50 by a suitable reservoir (not shown). Printhead 56 may be caused to eject droplets of ink 52 by a thermal mechanism or by an electro-mechanical mechanism. Printhead 56 may also use continuous ink flow technology.

Color light analyzer 20 preferably includes a light source 22 that emits a light beam 24 having a known spectral composition. Light beam 24 is directed at media 30 and is reflected by the media. Color light analyzer 20 receives the reflected light via sensor 28. The color content of the reflected light is then measured and a signal representing the color content is transmitted from color light analyzer 20 to controller 80. The color light analyzer 20 can be a densitometer, colorimeter, color scanner or spectrophotometer. In the embodiment of Fig. 3, color light analyzer 20 comprises a spectrophotometer.

The process of making calibration and color management adjustments to proofer 26 will now be described with reference to Figs. 2 and 3.

In the first step of the calibration process, controller 80 causes media advance 70 to position media 30 into position for printing. Controller 80 then accesses an electronic representation of a test image used for calibration. This electronic representation is stored in a controller memory 82. This electronic representation contains particular code values defining the colors to be printed at particular X-Y positions on media 30 to form test image 32. Alternatively, the electronic representation of test image 32 to be used for calibration can be stored on a device such as a data disk (not shown) or a computer network (not shown) and accessed by way of communication interface 84. Controller 80 positions

printhead 56 at particular X-Y coordinates on media 30 by the action of translation unit 60 and media advance 70. The controller 80 causes printhead 56 to eject ink droplets 52 to form the color patches 34 on the test image 32 in accordance with the code values in the electronic representation of the calibration
5 test image 32.

In the second step of the calibration process, controller 80 actuates the media advance 70 and translation unit 60 so that the color light analyzer 20 can scan each of the color patches 34. The color light analyzer 20 measures the spectral reflectance of each of the patches 34. Controller 80 receives the
10 measurement data from each of the color patches 34. Controller memory 82 contains code values associated with each of the patches of the characterization test image. Controller 80 then compares the color measured at each of patches 34 against the color code values associated with each of patches 34. From this comparison controller 80 then determines the adjustments that must be made to
15 cause printhead 56 to generate a particular color on media 30. Controller 80 then makes the calibration adjustments so that the printhead 56 renders images having the colors associated with the code values for the images.

Color management adjustments are made to the operation of proofer 26 using a characterization test image (not shown). The characterization
20 test image can be printed by the high volume output device or printed in accordance with a standard color proofing system. In either case, the characterization test image contains a number of color patches with each patch associated with a particular code value. The characterization test image is inserted into the media advance 70. Controller 80 then advances the color light analyzer
25 20 to each of the color patches and measures the color of each patch.

Controller memory 82 contains code values associated with each of the patches of the characterization test image. The colors measured at each of the patches by color light analyzer 20 are transmitted to controller 80 and compared to the code values associated with the patches. Controller 80 uses these comparisons
30 to build a device profile that predicts how the high volume output device will convert code values to colors on a printed image. Controller 80 then makes the color management adjustments in accordance with the profile.

To print the proof using proofer 26, the data representing an image, Ir, to be proofed is provided to interface 84 which converts this data into a form that is usable by controller 80. Controller 80 receives this data and modifies this data to reflect calibration adjustments and profile adjustments. Controller 80 then
5 transmits printing instructions to the printhead 56 in accordance with the adjusted data so that so that an image printed by the printhead 56 will visually match the appearance of the same image as printed the high volume output device.

It will be understood that it is also possible to accomplish the same result by using the calibration data and color adjustments to modify the way in
10 which controller 80 transforms color code values into printing instructions or by using calibration and color management adjustments to modify the way in which the printhead 56 transforms printing instructions into the release of ink 52.

It will also be understood that the time required to perform color calibration measurements can be reduced by using color light analyzer 20 to
15 measure the color patches 34 of test image 32 during the printing of test image 32.

Accordingly, both calibration and characterization of the proofer 26 is accomplished in the present invention with greatly reduced operator involvement and equipment cost as compared to the stand-alone color proofer arrangement of Fig. 1.

20 Fig. 4 shows a detailed embodiment of controller 80 of the present invention. In this embodiment, independent processors are used for image processing (120), color management (130), calibration (150), and control purposes (160). Each of the independent processors of Fig. 4 can comprise any of a
25 programmable digital computer, a programmable logic controller, a series of electronic circuits or a series of electronic circuits reduced to the form of an integrated circuit. It will readily be understood that it is possible to practice the present invention using other combinations of processors and electrical circuits to perform the required functions.

In the embodiment of Fig. 4, a media advance 70 and translation
30 unit 80, as generally described above, are provided for maneuvering proofing head 50 and media 30. Controller 160 operates media advance 70 and translation unit

60 to position the proofing head 50 at particular X-Y co-ordinates relative to media 30.

To make calibration adjustments, a test image 32 is generated by the proofer 26. Controller 160 maneuvers color light analyzer 20 into position to
5 measure the color content of the color patches 34 of calibration test image 32. The measurements are provided to a color calibrator 150. Color calibrator 150 calculates color density at particular patches 34 and compares these densities to the color densities that the printhead 56 was instructed to print. From this, the color calibrator 150 generates a calibration look up table (CaLUT). The CaLUT
10 correlates color code values in the electronic image data to the color code values that must actually be used during printing to cause the printhead 56 to generate the desired colors in the printed image. During printing, color calibrator 150 modifies the code values in the data representing the image to be printed in accordance with the CaLUT.

15 To make color management adjustments, a characterization test image (not shown) having color patches printed by the high volume output device or printed in accordance with an industry standard, is inserted into the media advance 70. Controller 160 causes media translation unit 60 to color light analyzer 20 into positions to measure color content of the color patches of the
20 characterization test image. The measurements are provided to color image processor 130. Color image processor 130 generates a color profile of the data measured from the test image using one or more profiling techniques known in the art. Examples of software embodying these techniques include CompassProFile™ software sold by Color Savvy Systems, Ltd. of Springboro, Ohio, and KODAK
25 COLORFLOW ICC Profile Editor sold by Eastman Kodak Company of Rochester, NY. The profile takes the form of a three or four dimensional Look Up Table (ChLUT), depending upon the number of color channels in the image. The color image processor 130 can comprise a trilinear or quadlinear interpolation processor (not shown) to modify the color code values in the electronic data
30 representing an image in accordance with the ChLUT.

During proofing operations, electronic data representing the image to be proofed is transmitted to the proofer 26. This data, Ir, is accepted by the

proofer 26 by way of an image source 110. Image source 110 can comprise any convenient interface for accepting Ir from an external source and making Ir available for processing and printing by the proofer 26. Image source 110 can include systems for receiving and decoding magnetic or optical disk drives and flash memory cards. Image source 110 can also include systems for receiving electronic signals from computers, computer networks, and other devices. These signals may take the form of raster image data, outline image data in the form of a page description language or other forms of digital representation.

Image source 110 is coupled to an image processor 120 that converts the image data Ir from image source 110 into a pixel-mapped page image Ipm. Color image processor 130 processes the pixel-mapped image Ipm, using the ChLUT to form a processed image Ip. This modifies the image, Ip, so that the color gamut and tone characteristics of the code values in the processed image Ip match the color gamut and tone characteristics of the output of the high volume output device that has been profiled. After processing, the processed image Ip is stored in memory 140 until the processed image, Ip, is needed for printing.

To print the proof, processed image Ip is fed from memory 140 to previously mentioned calibrator 150. Calibrator 150 modifies the processed image Ip using the CaLUT to produce a calibrated image Ic. This calibrated image Ic is then fed to the printer controller 160. Printer controller 160 determines, from this data, the colors to be used in the image, and where these colors are to be deposited on a receiver media 30. Controller 160 advances the printhead 56 and media 30 to any X-Y coordinate by operation of the translation unit 60 and media advance 70. Printer controller 160 then applies a time-varying electrical pulse to the printhead 56 to eject a combination of ink droplets 52 from printhead 56 in accordance with the calibrated image Ic.

The proofer 26 of Fig. 4, therefore, modifies image data twice before printing: once to ensure that the colors of the printed image properly reflect the colorimetric characteristics of a high volume output device and once to ensure that the printhead 56 creates the desired colors on a particular receiver media 30.

It will also be appreciated that proofer 26 can be configured to automatically execute both calibration adjustments and color management

adjustments with a minimum of operator involvement. In the system shown in Fig. 5, the media advance 70 can be supplied by a media supply source such as a tray 78. Tray 78 is configured to contain more than one sheet of media 30, and to supply the media 30 to the media advance 70 in an orderly fashion. With this arrangement, a user can insert a receiver media 30 and a second media 31 having a test image 33 printed by a high volume output device into the tray 78. Controller 80 is programmed to execute both calibration and color management adjustments using these images. After calibration and color management adjustments, the proofer 26 is ready to generate a visually accurate proof.

It will be understood that printing conditions can change during the printing of the proof. These changes can alter the color content of an image printed by printhead 56 on a receiver media 30. To prevent this, proofer 26 of the present invention can be configured so that the light reflecting from colors printed by printhead 56 on a media 30 is measured by the color light analyzer 20 during printing. Controller 80 can then make printer calibration adjustments in response to real-time color measurements.

It will also be understood that circumstances may arise wherein the printhead 56 cannot be made to print the desired colors on the media 30. For example, this can occur because a supply of an ink is exhausted or because the printhead 56 is clogged or damaged. In such circumstances, no adjustment of the calibration can compensate for the problem, thus, controller 80 can be programmed to stop printing or to provide the user with a warning that calibration errors occurred during printing. This warning can comprise a written warning printed on the image, an interruption of the printing process or other forms of aural or visual notification.

As is shown in Fig. 6, one particularly valuable application of the proofing head 50 of the present invention is for a proofing head 50 that can be installed into a conventional printer 200, having a predefined printhead mounting area 210. Printer controller 212 controls the operation of printer media advance 230 and printhead translation unit 220. An electrical connection 214 is also defined between printer controller 212 and printhead mounting area 210 to allow the printer controller 212 to govern the operation of a conventional printhead to

216 (not shown). Media advance 230 comprises a media roller 232 and pinch roller 234. A motor 236 drives the operation of roller 232 to advance a sheet of media 240 along a Y-axis. Translation unit 220 can movably position the mounting area 210 relative to the media along an X-axis by rotating drive pinion 268 to drive belt 264 and pinion 266. The printer 200 operates as does any conventional printer and, does not have any inherent structure for performing calibration or characterization operations.

Proofing head 50 is installed in the predefined printhead mounting area 210. To accommodate this, housing 40 is shaped to fit into printhead mounting area 210. In this embodiment, housing 40 comprises an inner chamber 41 that contains controller 80, printhead 56 and color light analyzer 20. In this embodiment, the controller 80 is electrically connected to controller 212 by way of the electrical connection 214. In this manner, the printing instructions transmitted by the printer controller 212 are received by the controller 80 of the proofing head 52.

Once installed into the printhead mounting area 210, proofing head 50 is used to execute printer calibration and characterization adjustments. In this respect, controller 80 of proofing head 50 is connected to printer controller 212 to cause printer controller 212 to operate translation unit 220 and media advance 230 to allow for the creation of a calibration test image and to allow for the color measurement of calibration and characterization test images as generally described above. Alternatively, printer 200 can be connected to an external computer 250, which directs printer controller 212 to maneuver proofing head 50 to particular locations in order to allow the proofer to perform calibration and characterization operations, as generally described above.

During printing, the printer controller 212 transmits printing instructions to controller 80. Controller 80 modifies the printing instructions in accordance with color calibration and color management adjustments so that an image printed by printer 200 will have the same visual appearance as the same image when printed by a high volume printer or output device. In one embodiment of the present invention, controller 80 uses color light analyzer 20 to ensure that the colors that are printed by printhead 56 onto a media 240 during

printing match the colors that the controller 80 has instructed the printhead 56 to print. If these colors do not match, controller 80 modifies the operation of the printhead 56.

Thus, as is shown and described, the proofing head 56 can be
5 incorporated into a conventional printer to provide calibration and proofing capabilities to such a printer 210 without substantial modification to the existing printer design.

The invention has been described in detail with particular reference
to certain preferred embodiments thereof, but it will be understood that variations
10 and modifications can be effected within the spirit and scope of the invention.

11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000
1001
1002
1003
1004
1005
1006
1007
1008
1009
1010
1011
1012
1013
1014
1015
1016
1017
1018
1019
1020
1021
1022
1023
1024
1025
1026
1027
1028
1029
1030
1031
1032
1033
1034
1035
1036
1037
1038
1039
1040
1041
1042
1043
1044
1045
1046
1047
1048
1049
1050
1051
1052
1053
1054
1055
1056
1057
1058
1059
1060
1061
1062
1063
1064
1065
1066
1067
1068
1069
1070
1071
1072
1073
1074
1075
1076
1077
1078
1079
1080
1081
1082
1083
1084
1085
1086
1087
1088
1089
1090
1091
1092
1093
1094
1095
1096
1097
1098
1099
1100
1101
1102
1103
1104
1105
1106
1107
1108
1109
1110
1111
1112
1113
1114
1115
1116
1117
1118
1119
1120
1121
1122
1123
1124
1125
1126
1127
1128
1129
1130
1131
1132
1133
1134
1135
1136
1137
1138
1139
1140
1141
1142
1143
1144
1145
1146
1147
1148
1149
1150
1151
1152
1153
1154
1155
1156
1157
1158
1159
1160
1161
1162
1163
1164
1165
1166
1167
1168
1169
1170
1171
1172
1173
1174
1175
1176
1177
1178
1179
1180
1181
1182
1183
1184
1185
1186
1187
1188
1189
1190
1191
1192
1193
1194
1195
1196
1197
1198
1199
1200
1201
1202
1203
1204
1205
1206
1207
1208
1209
1210
1211
1212
1213
1214
1215
1216
1217
1218
1219
1220
1221
1222
1223
1224
1225
1226
1227
1228
1229
1230
1231
1232
1233
1234
1235
1236
1237
1238
1239
1240
1241
1242
1243
1244
1245
1246
1247
1248
1249
1250
1251
1252
1253
1254
1255
1256
1257
1258
1259
1260
1261
1262
1263
1264
1265
1266
1267
1268
1269
1270
1271
1272
1273
1274
1275
1276
1277
1278
1279
1280
1281
1282
1283
1284
1285
1286
1287
1288
1289
1290
1291
1292
1293
1294
1295
1296
1297
1298
1299
1300
1301
1302
1303
1304
1305
1306
1307
1308
1309
1310
1311
1312
1313
1314
1315
1316
1317
1318
1319
1320
1321
1322
1323
1324
1325
1326
1327
1328
1329
1330
1331
1332
1333
1334
1335
1336
1337
1338
1339
1340
1341
1342
1343
1344
1345
1346
1347
1348
1349
1350
1351
1352
1353
1354
1355
1356
1357
1358
1359
1360
1361
1362
1363
1364
1365
1366
1367
1368
1369
1370
1371
1372
1373
1374
1375
1376
1377
1378
1379
1380
1381
1382
1383
1384
1385
1386
1387
1388
1389
1390
1391
1392
1393
1394
1395
1396
1397
1398
1399
1400
1401
1402
1403
1404
1405
1406
1407
1408
1409
1410
1411
1412
1413
1414
1415
1416
1417
1418
1419
1420
1421
1422
1423
1424
1425
1426
1427
1428
1429
1430
1431
1432
1433
1434
1435
1436
1437
1438
1439
1440
1441
1442
1443
1444
1445
1446
1447
1448
1449
1450
1451
1452
1453
1454
1455
1456
1457
1458
1459
1460
1461
1462
1463
1464
1465
1466
1467
1468
1469
1470
1471
1472
1473
1474
1475
1476
1477
1478
1479
1480
1481
1482
1483
1484
1485
1486
1487
1488
1489
1490
1491
1492
1493
1494
1495
1496
1497
1498
1499
1500
1501
1502
1503
1504
1505
1506
1507
1508
1509
1510
1511
1512
1513
1514
1515
1516
1517
1518
1519
1520
1521
1522
1523
1524
1525
1526
1527
1528
1529
1530
1531
1532
1533
1534
1535
1536
1537
1538
1539
1540
1541
1542
1543
1544
1545
1546
1547
1548
1549
1550
1551
1552
1553
1554
1555
1556
1557
1558
1559
1560
1561
1562
1563
1564
1565
1566
1567
1568
1569
1570
1571
1572
1573
1574
1575
1576
1577
1578
1579
1580
1581
1582
1583
1584
1585
1586
1587
1588
1589
1590
1591
1592
1593
1594
1595
1596
1597
1598
1599
1600
1601
1602
1603
1604
1605
1606
1607
1608
1609
1610
1611
1612
1613
1614
1615
1616
1617
1618
1619
1620
1621
1622
1623
1624
1625
1626
1627
1628
1629
1630
1631
1632
1633
1634
1635
1636
1637
1638
1639
1640
1641
1642
1643
1644
1645
1646
1647
1648
1649
1650
1651
1652
1653
1654
1655
1656
1657
1658
1659
1660
1661
1662
1663
1664
1665
1666
1667
1668
1669
1670
1671
1672
1673
1674
1675
1676
1677
1678
1679
1680
1681
1682
1683
1684
1685
1686
1687
1688
1689
1690
1691
1692
1693
1694
1695
1696
1697
1698
1699
1700
1701
1702
1703
1704
1705
1706
1707
1708
1709
1710
1711
1712
1713
1714
1715
1716
1717
1718
1719
1720
1721
1722
1723
1724
1725
1726
1727
1728
1729
1730
1731
1732
1733
1734
1735
1736
1737
1738
1739
1740
1741
1742
1743
1744
1745
1746
1747
1748
1749
1750
1751
1752
1753
1754
1755
1756
1757
1758
1759
1760
1761
1762
1763
1764
1765
1766
1767
1768
1769
1770
1771
1772
1773
1774
1775
1776
1777
1778
1779
1780
1781
1782
1783
1784
1785
1786
1787
1788
1789
1790
1791
1792
1793
1794
1795
1796
1797
1798
1799
1800
1801
1802
1803
1804
1805
1806
1807
1808
1809
1810
1811
1812
1813
1814
1815
1816
1817
1818
1819
1820
1821
1822
1823
1824
1825
1826
1827
1828
1829
1830
1831
1832
1833
1834
1835
1836
1837
1838
1839
1840
1841
1842
1843
1844
1845
1846
1847
1848
1849
1850
1851
1852
1853
1854
1855
1856
1857
1858
1859
1860
1861
1862
1863
1864
1865
1866
1867
1868
1869
1870
1871
1872
1873
1874
1875
1876
1877
1878
1879
1880
1881
1882
1883
1884
1885
1886
1887
1888
1889
1890
1891
1892
1893
1894
1895
1896
1897
1898
1899
1900
1901
1902
1903
1904
1905
1906
1907
1908
1909
1910
1911
1912
1913
1914
1915
1916
1917
1918
1919
1920
1921
1922
1923
1924
1925
1926
1927
1928
1929
1930
1931
1932
1933
1934
1935
1936
1937
1938
1939
1940
1941
1942
1943
1944
1945
1946
1947
1948
1949
1950
1951
1952
1953
1954
1955
1956
1957
1958
1959
1960
1961
1962
1963
1964
1965
1966
1967
1968
1969
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
2022
2023
2024
2025
2026
2027
2028
2029
2030
2031
2032
2033
2034
2035
2036
2037
2038
2039
2040
2041
2042
2043
2044
2045
2046
2047
2048
2049
2050
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
2064
2065
2066
2067
2068
2069
2070
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
2084
2085
2086
2087
2088
2089
2090
2091
2092
2093
2094
2095
2096
2097
2098
2099
2100
2101
2102
2103
2104
2105
2106
2107
2108
2109
2110
2111
2112
2113
2114
2115
2116
2117
2118
2119
2120
2121
2122
2123
2124
2125
2126
2127
2128
2129
2130
2131
2132
2133
2134
2135
2136
2137
2138
2139
2140
2141
2142
2143
2144
2145
2146
2147
2148
2149
2150
2151
2152
2153
2154
2155
2156
2157
2158
2159
2160
2161
2162
2163
2164
2165
2166
2167
2168
2169
2170
2171
2172
2173
2174
2175
2176
2177
2178
2179
2180
2181
2182
2183
2184
2185
2186
2187
2188
2189
2190
2191
2192
2193
2194
2195
2196
2197
2198
2199
2200
2201
2202
2203
2204
2205

PARTS LIST

- 10 stand-alone proofer
- 12 stand-alone color measurement device
- 14 high volume output device
- 16 calibration test image
- 17 color patches
- 18 characterization test image
- 19 color patches
- 20 color light analyzer
- 22 light source
- 24 light beam
- 26 proofer
- 28 sensor
- 30 media
- 31 second Media
- 32 calibration test image
- 33 characterization test image
- 34 color patches
- 37 media plane
- 40 housing
- 42 opening in housing
- 50 proofing head
- 52 ink
- 56 printhead
- 60 translation unit
- 62 motor
- 64 belt
- 66 support pinion
- 68 drive pinion
- 70 media advance
- 72 motor
- 74 pinch rollers

76	media supply source
78	tray
80	controller
82	controller memory
84	controller interface
110	image source
120	image processor
130	color image processor
140	image memory
150	color calibrator
160	printhead controller
200	conventional printer
210	predefined printhead mounting area
212	printer controller
214	electrical connection
216	conventional printhead
220	translation unit
230	media advance
232	media roller
234	pinch roller
236	motor
250	conventional computer
264	belt
266	support pinion
268	drive pinion